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13. ABSTRACT (Maximum 200 words)  We studied the chemical nature of the substrate and the role of buffer layers on nucleation and growth of diamond during chemical vapor deposition (hot-filament). The transition metals with partially filled d-atomic orbitals are found to stabilize SP <sup>2</sup> bonding which leads to enhanced precipitation of SP <sup>2</sup> bonded non-diamond carbon phases such as graphite, amorphous and glassy carbon films. We have shown that by alloying these metals with electron donating elements, it is possible to stabilize SP <sup>3</sup> bonding and form diamond film directly on the metallic substrates. Similar studies on nucleation and growth of diamond have been performed using AlN buffer layers. The results from these studies are compared with those obtained using buffer layers. By using these concepts, we have minimized the formation of graphitic layers and improved the adhesion of diamond layers on non-carbide forming metallic substrates.			
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Report

**Nucleation, Growth and Defect Engineering in Diamond Thin films**

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With the advent of recent developments in low pressure CVD techniques for diamond deposition, it has been possible to synthesize diamond in thin film/coating configuration on a given solid surface well as in a form of self standing film and ribbon. Since diamond possesses novel combination of physical and chemical properties, these films and coatings can be effectively utilized in a variety of applications ranging from cutting/grinding tools to optical windows to high temperature, high speed electro-optic devices. Consequently, science and technology of CVD-diamond has emerged as front-line research area in materials science. In recent years a considerable progress has been made in this field and some general features of formation of diamond films on a variety of substrate materials have been established. However, the basic physical processes of nucleation and growth of CVD-diamond are not yet fully understood. The aspects

of nucleation, growth and adhesion of diamond on non-diamond substrates are of prime importance in achieving high quality diamond coatings that have technological value. In the following, we have summarized results of our research efforts in this project.

In the initial phase of this project we embarked upon nucleation, growth and adhesion studies on transition metals to achieve desired diamond coatings. It is recognized that these metals, with their unfilled 'd' atomic orbitals, possess high catalytic activity which tends to stabilize  $sp^2$  bonding in CVD diamond deposit. This leads to enhanced precipitation of  $sp^2$  bonded non-diamond carbon phases such as graphite, amorphous or glassy carbon, diamondlike carbon (DLC) instead of  $sp^3$  bonded diamond, during initial period of deposition experiment. In the latter stages of deposition some nucleation and growth of diamond on the top of this layer also occurs. Due to the interposing layer of nondiamond carbon, the resulting diamond films exhibit extremely poor adhesion properties. In our studies, we have investigated the use of alloying with electron rich element such as Aluminum(Al), for lowering catalytic activity of metals such as iron (Fe) and nickel(Ni). Further details are provided in references (1,2 ).

In other studies, we have followed the concept of using a buffer layer to overcome catalytic effects during diamond deposition on transition metals. These investigations have led to development of aluminum nitride(AlN) as an excellent buffer layer material for CVD-diamond. It is found that AlN plays a variety of roles. It acts as an excellent diffusion barrier for carbon, inhibits graphite phase formation and simultaneously offers diamond nucleation via formation of surface carbide. It is very stable in the CVD-environment, and the thermal expansion coefficient and its variation with temperature has a close match with that of diamond. These characteristics improve adhesion coatings with metal substrate.

All these properties make AlN as a potential candidate for integration with diamond. Good quality diamond films are obtained on nickel, iron and different steel substrates by using AlN as a buffer layer. AlN has been further utilized to synthesize wear resistant composite coatings with diamond on copper (Cu), silicon (Si) and steel substrates. By appropriately controlling deposition parameters, composite coatings have been synthesized in which diamond matrix formed a cellular structure in the background matrix of AlN. By using indigenously developed method, wear resistance measurements of these composites are carried out. The composites are found to possess high wear resistance. More details regarding all these studies are given in references (3-4).

### **References/Publications :**

1. X.Chen and J. Narayan, "Effect of chemical nature of transition-metal substrates on chemical vapor deposition of diamond", *J. Appl. Phys.* **74**(6), 4168 91993)
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4. V.P. Godbole and J.Narayan; " Synthesis of wear resistant Aluminum Nitride-diamond composite coatings on silicon, copper and steels", *Mat. Sci. & Eng. B* (submitted)

-No patents have been filed from this research.